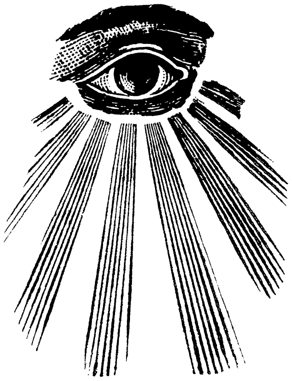
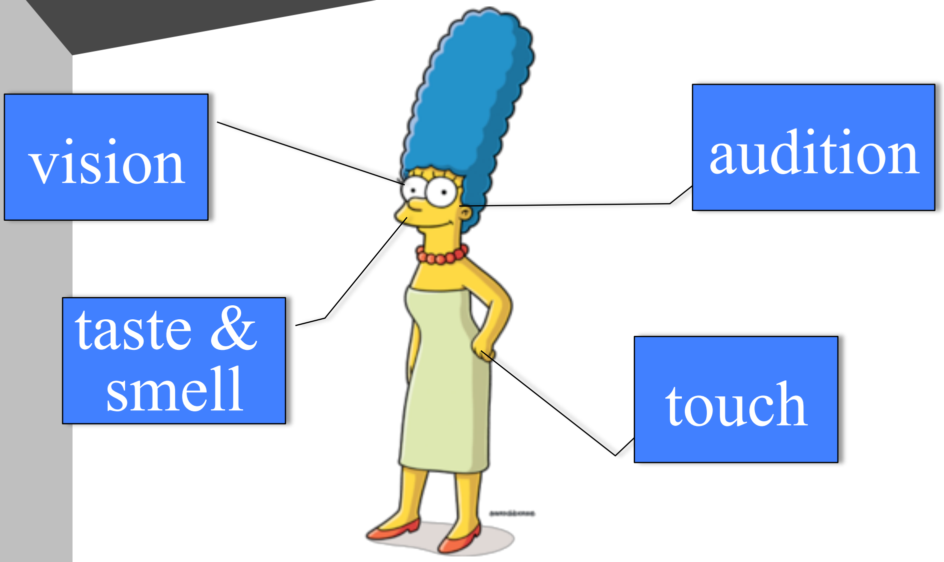
PERCEPTION

VISUAL, AUDITORY, MULTIMODAL



Harder than it seems . . .

Perceptual Systems



vision

audition

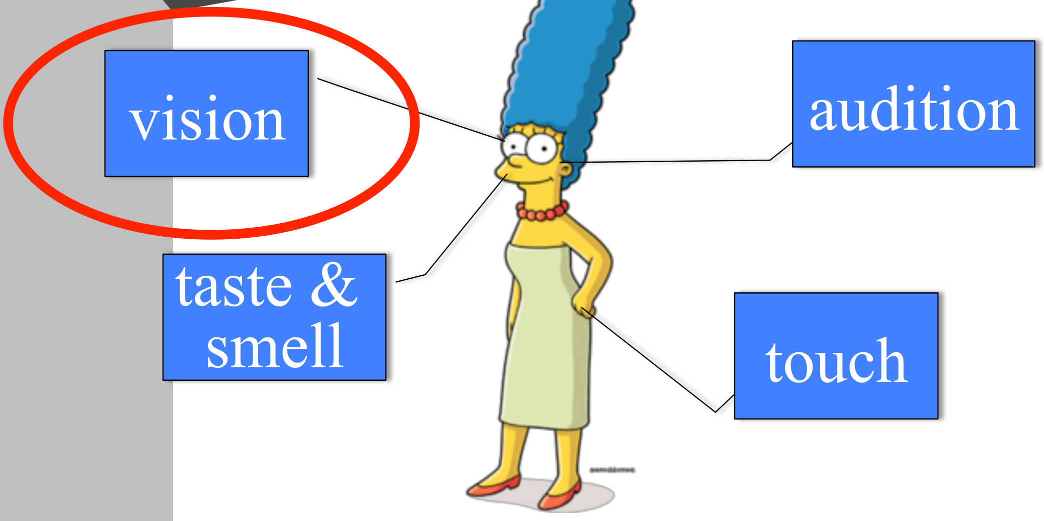
taste & smell

touch

Perceptual Systems

- Perceptual systems are…
  - a snapshot of the world?
  - an interpretation of the world?

Perceptual Systems



vision

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VISION: The brain's camera?

What are the goals of vision?

- Accurately record the color, intensity, etc. of light?
- NO! Recognize objects ...
  - *What* objects are out there?
  - *Where* are they?
  - *How* are they moving?

Harder than it "looks" …

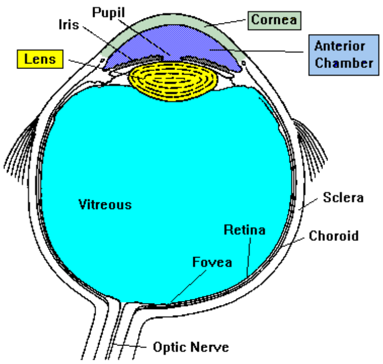
AMBIGUITY!

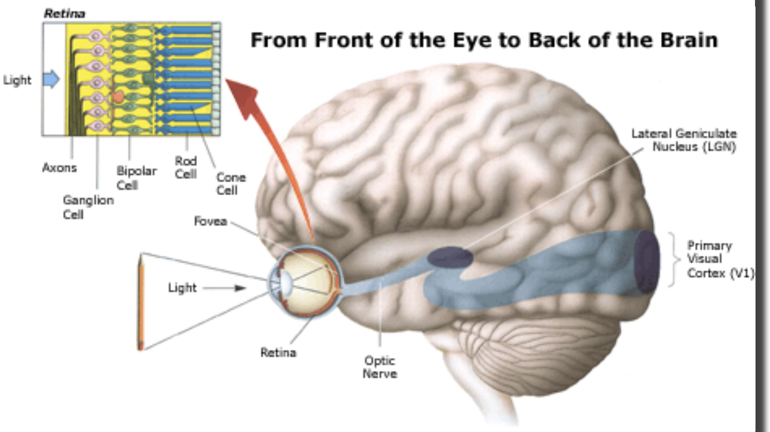
= more than one possible interpretation

"Whatever job you give him, I have no doubt that he will be fired with enthusiasm."

Harder than it “looks” …

Have to construct a 3-D representation from a 2-D pattern of light on the retina; this is an “indeterminant” problem.




Retina
Light
Axons
Bipolar Cell
Rod Cell
Cone Cell
Ganglion Cell
From Front of the Eye to Back of the Brain
Lateral Geniculate Nucleus (LGN)
Fovea
Primary Visual Cortex (V1)
Light
Retina
Optic Nerve

Inverse optics problem

Consider that objects . . .

-- can be seen from many orientations

-- can be lit in different ways

-- can be seen at different distances

-- can be occluded by other objects

Example: Determining color

- Think about how to design a system that detects whether an object is red, blue, or purple …

The perceived color of objects depends on what frequencies of light those objects absorb versus reflect.

Color

- Assume red objects reflect 80% of the red light that hits them and only 10% of the blue light.
- Assume purple objects reflect 50% red, 50% blue.
- Assume blue objects reflect 80% of the blue light and 10% of the red.

Simple color determination

- Light comes in with 100 units of red and 100 units of blue:

	Red object	**Purple object**	**Blue object**
Red light	80	50	10
Blue light	10	50	80

Simple color determination

- But what if the light source changes?
  - *is perception the same?*

But … light sources differ

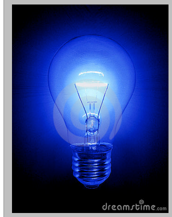
- Light comes in with 10 units of red and 190 units of blue:

	Red object	Purple object	Blue object
Red light	8	5	1
Blue light	19	95	152

Not so simple color determination

- Light comes in with 100 units of red and 100 units of blue:

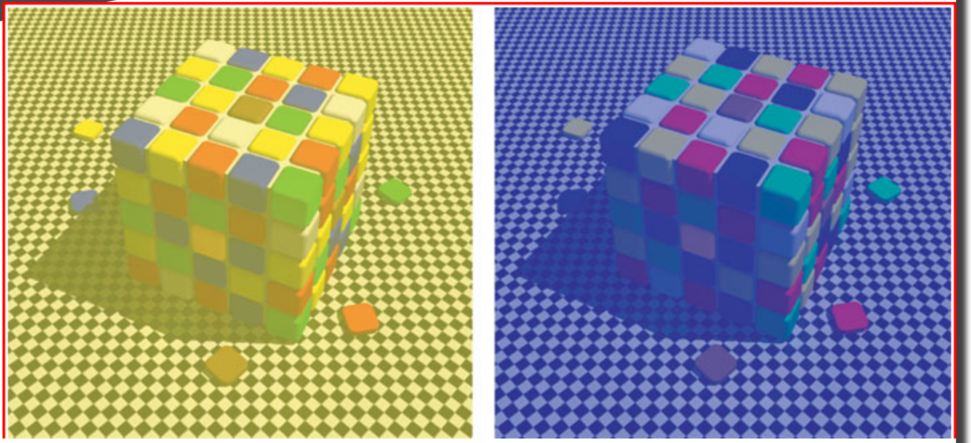
	Red object	Purple object	Blue object
Red light	80	50	10
Blue light	10	50	80

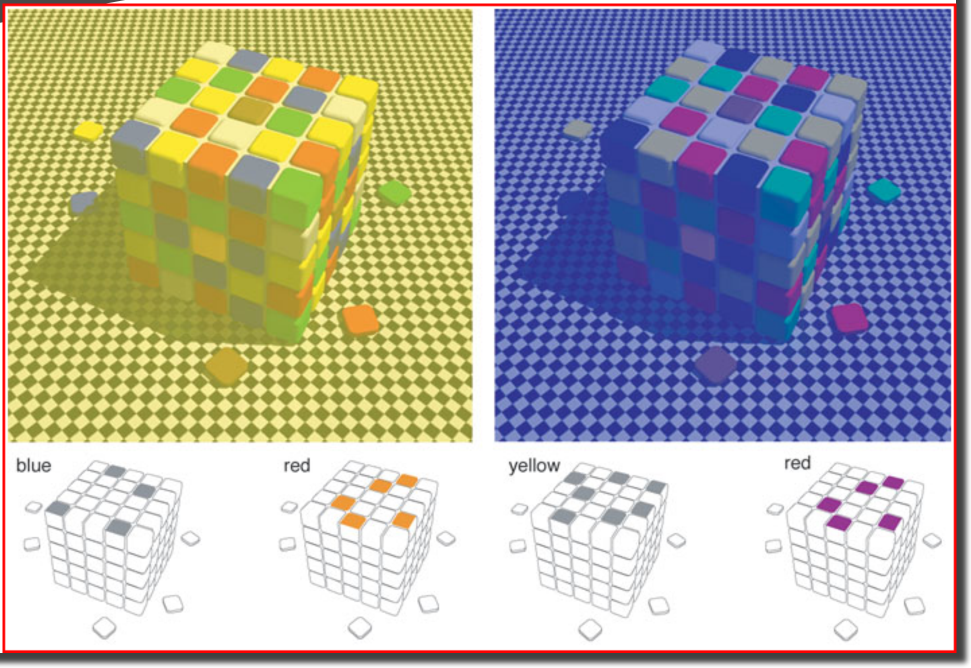


- Light comes in with 10 units of red and 190 units of blue:

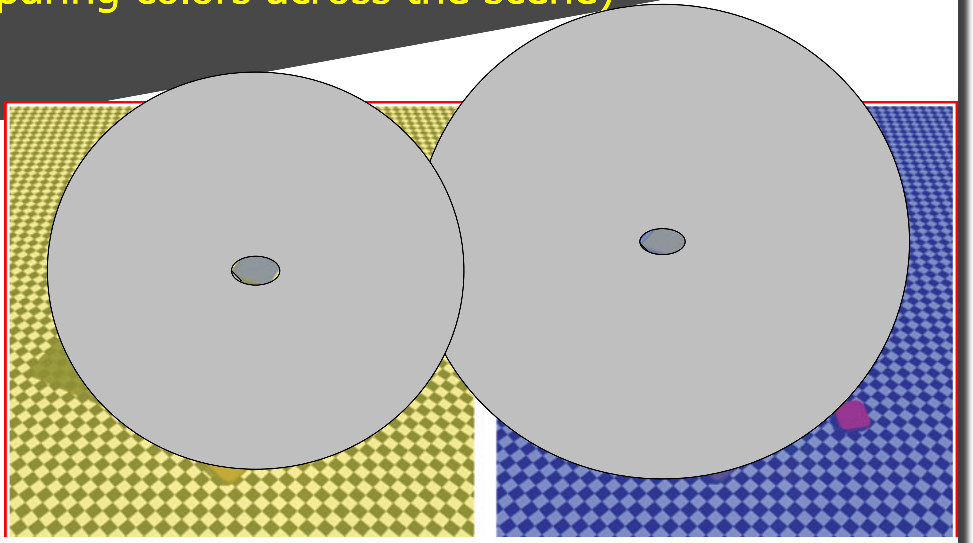
	Red object	Purple object	Blue object
Red light	8	5	1
Blue light	19	95	152

How do we solve this??





The brain solves this by *normalizing* (comparing colors across the scene)



Blue square second from right

Yellow square second from left

How does the brain deal with ambiguity?

Three key strategies

- Use context (contrasts)
- Make assumptions
- Use “top-down” information

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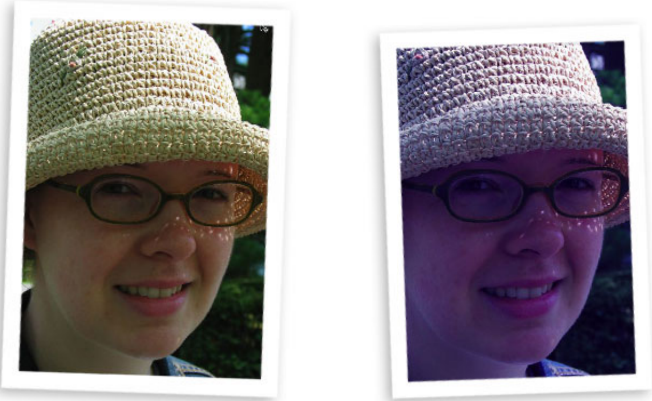
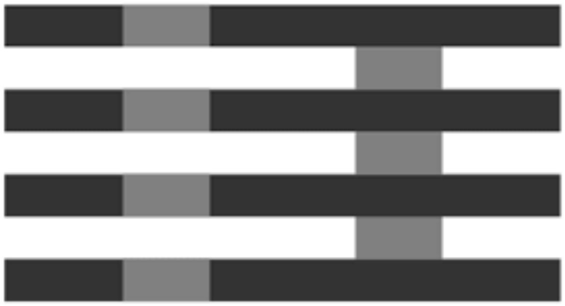
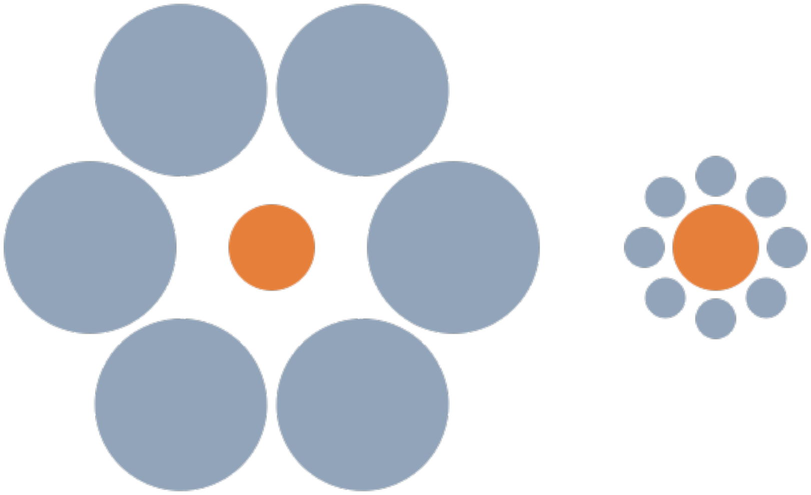
Color constancy



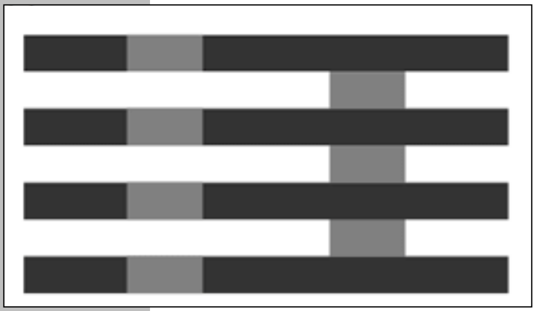
Vision in context

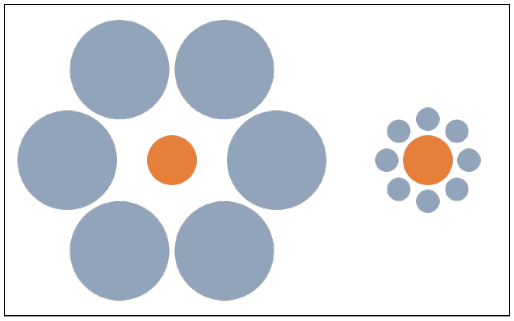


Context and size



Context drives perception





Recap: context

The visual system *compares* the input it gets from region to region.

Sharp differences tend to get *accentuated*.
This is good for processes like finding edges.

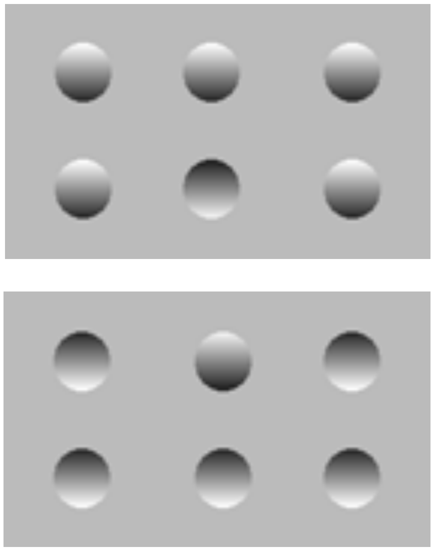
Constant factors tend to get *ignored*.
This is good for dealing with variability.

How do we solve it?

Three key strategies

- Use context (contrasts)
- Make assumptions
- Use “top-down” information

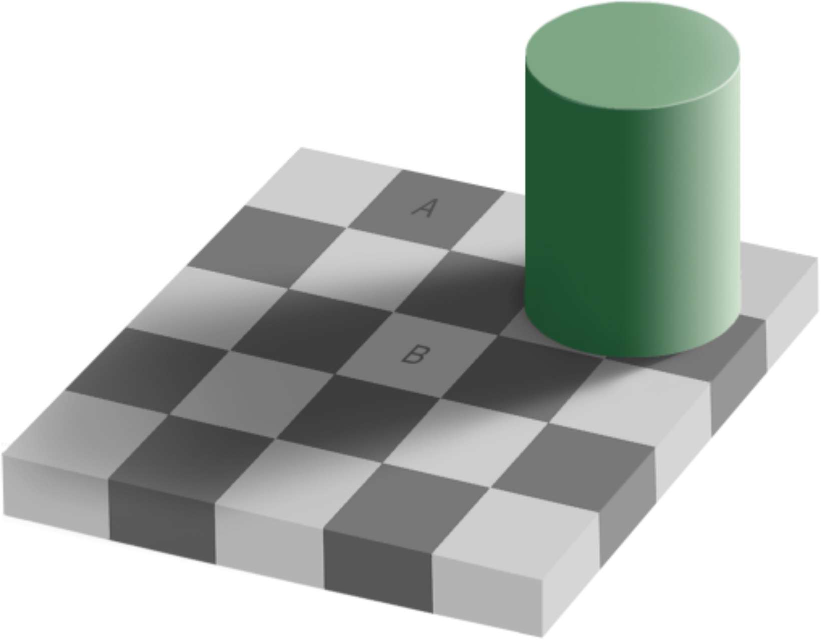
Shading ambiguities



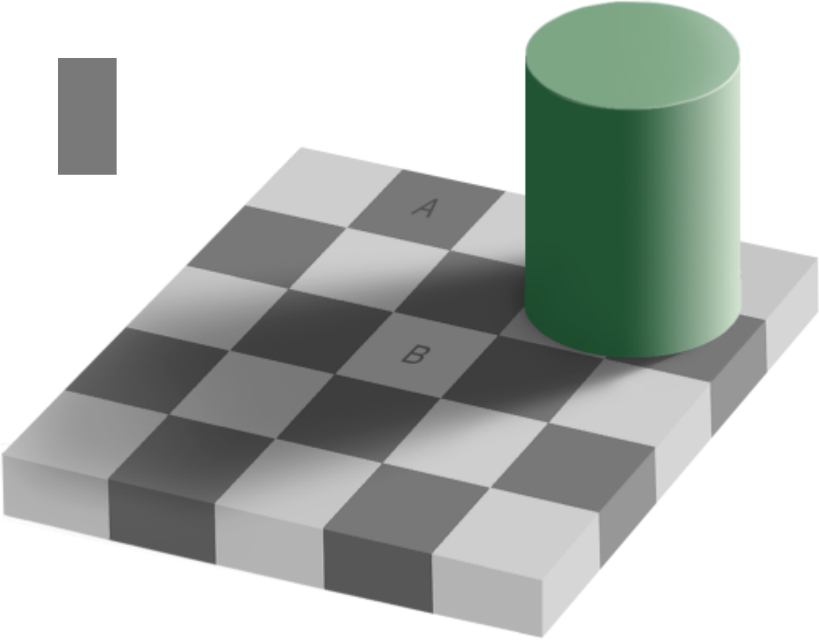
Assumptions about light

- Light source comes from above.
- For fun, also take a look at:
  - www.michaelbach.de/ot/fcs_hollow-face/index.html

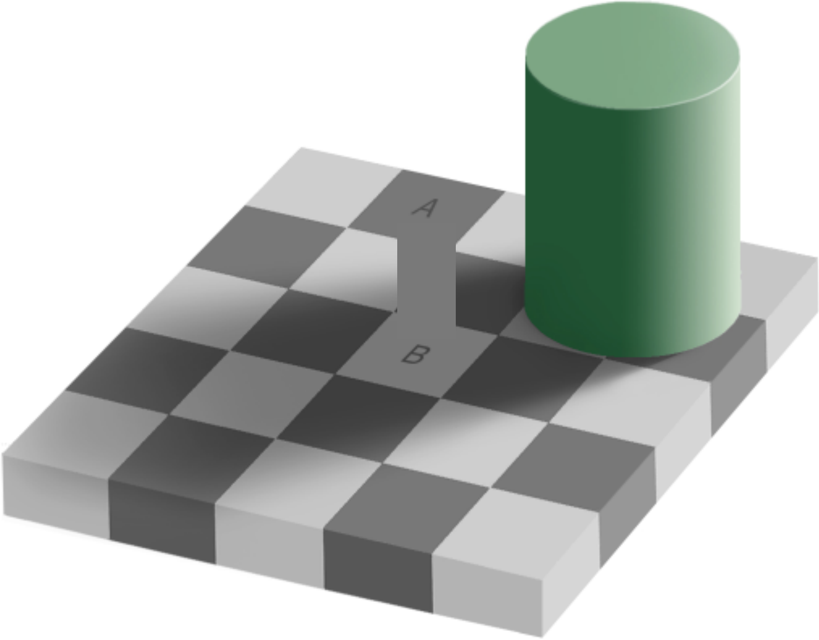
Another example



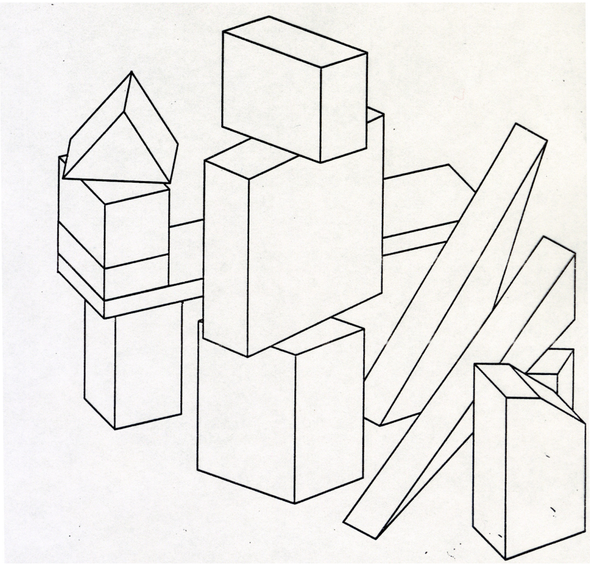
Another example



Another example



Grouping: what goes together

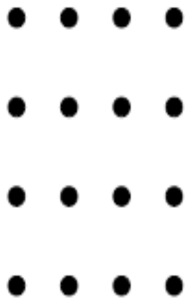


Assumptions about grouping

some Gestalt principles

Proximity
Similarity
Good continuation
Closure (“Pragnanz”)

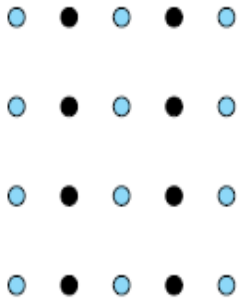
Proximity



Do you see rows or columns?

Could be either, but objects are closer together in the rows, so we tend to see rows.

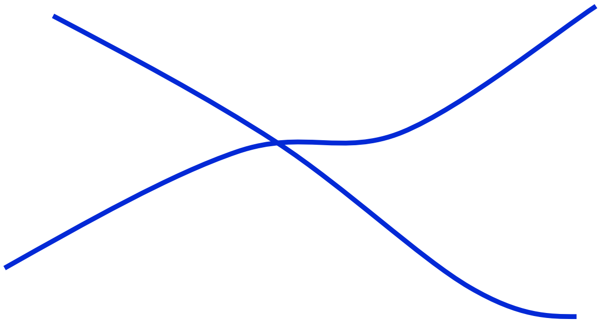
Similarity



Do you see rows or columns?

Tend to group together similar items, so in this case people tend to see columns.

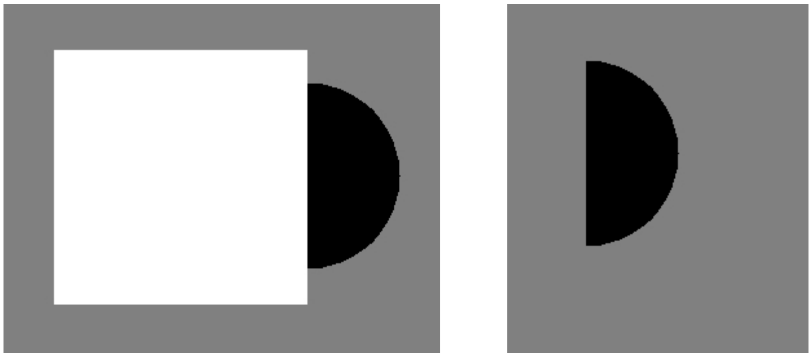
Good continuation



Four lines? Two “v” shapes? Two long lines?

Tend to assume that entities that lie along
a continuous line or surface are “one” object.

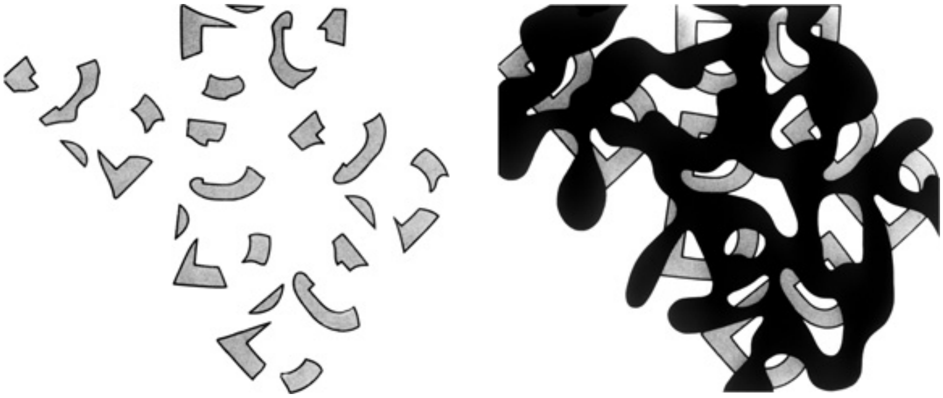
Closure



What do you see?

We tend to assume that shapes are closed and
to “fill in” information that appears occluded.

Closure at work



Recap: assumptions

- The visual system makes assumptions about typical viewing conditions and about what parts of a visual scene go together.
  - not conscious or strategic (can’t be turned off)
  - are sometimes misleading, but usually work well

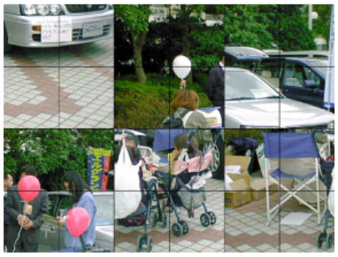
How do we solve it?

Three key strategies

- Use context (contrasts)
- Make assumptions
- Use “top-down” information

Knowledge and object recognition

Recognition is faster for objects in a coherent scene than in a jumbled one.

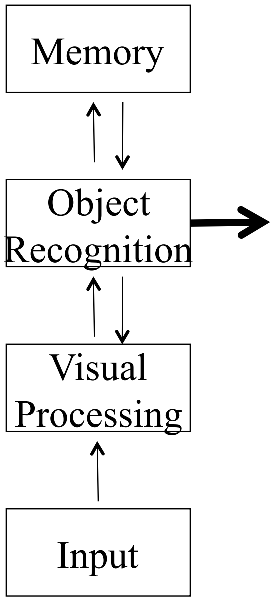


(b)

Knowledge and object recognition

Recognition is faster and more accurate for objects in a congruent scene than in an incongruent scene.

What does this say about our model of visual perception?



Memory

Object Recognition

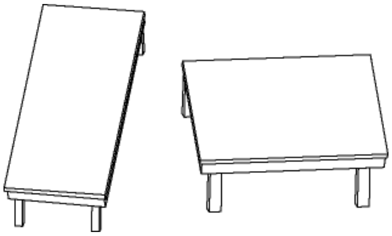
Visual Processing

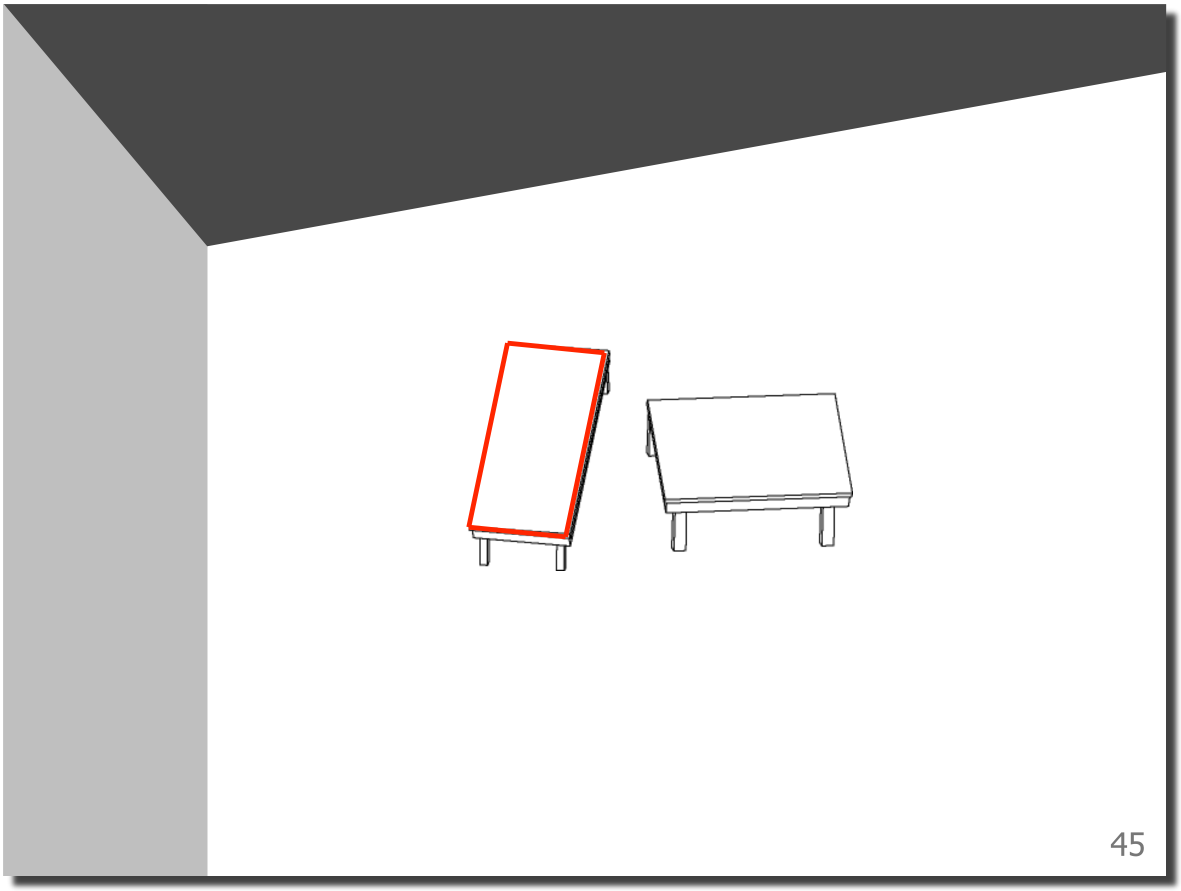
Input

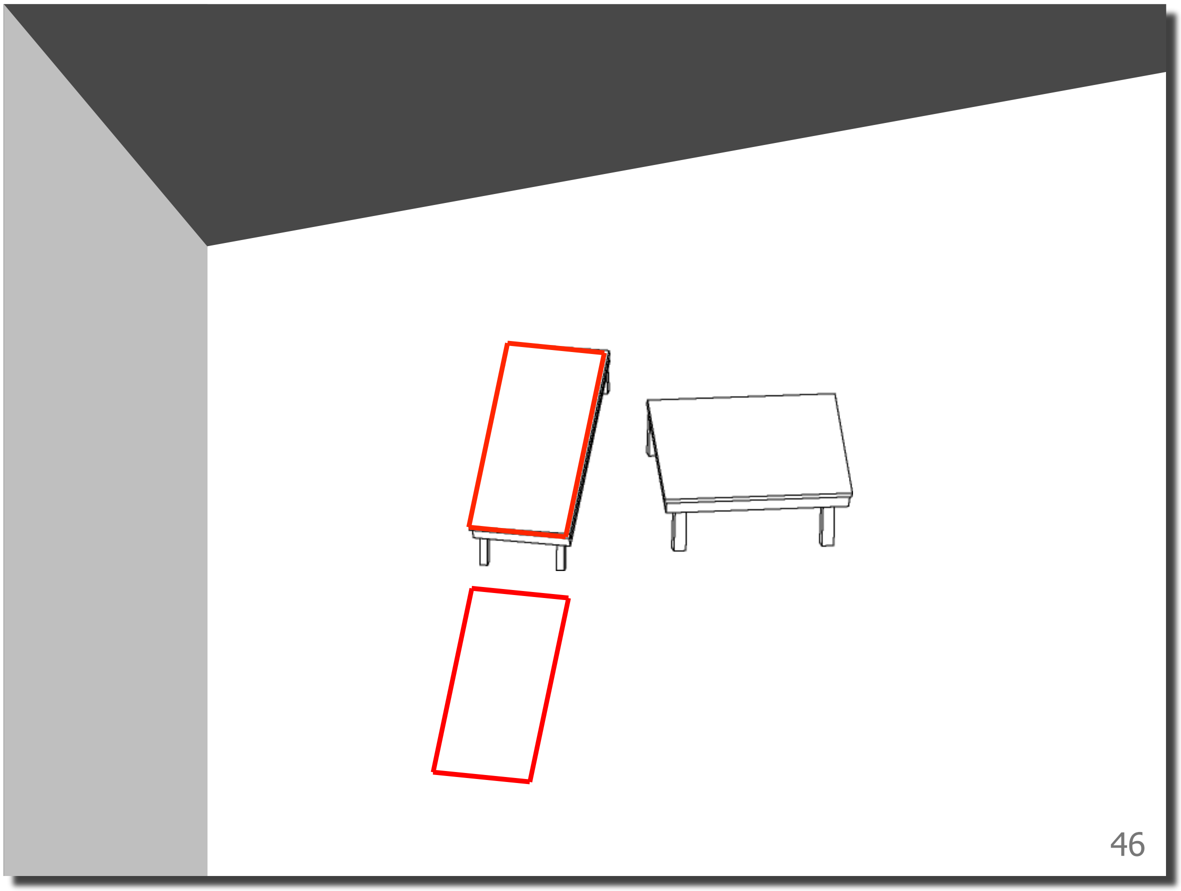
Vision: Summary

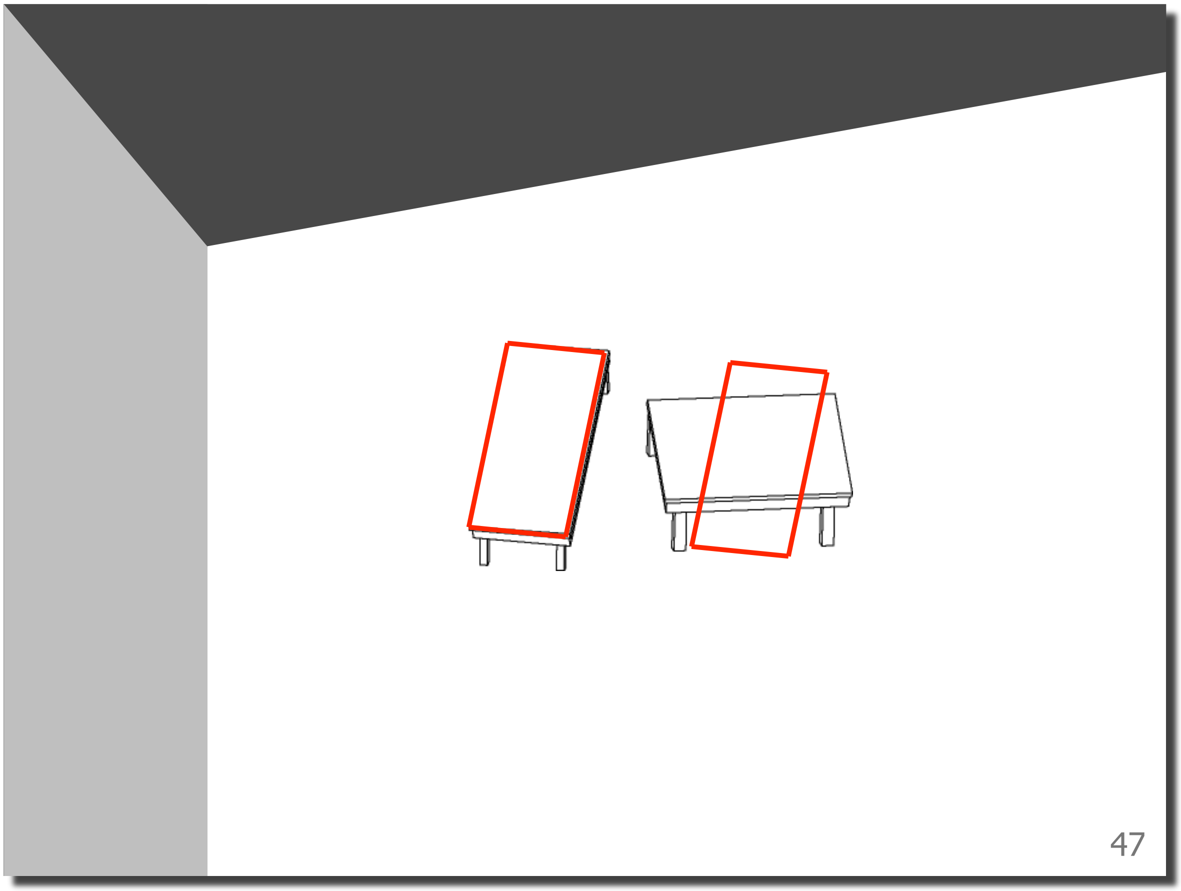
- Vision is a process that creates a 3d representation from 2d input
  - perceiving the input
  - integrating with context
    - memory, the world
  - interpreting ambiguity

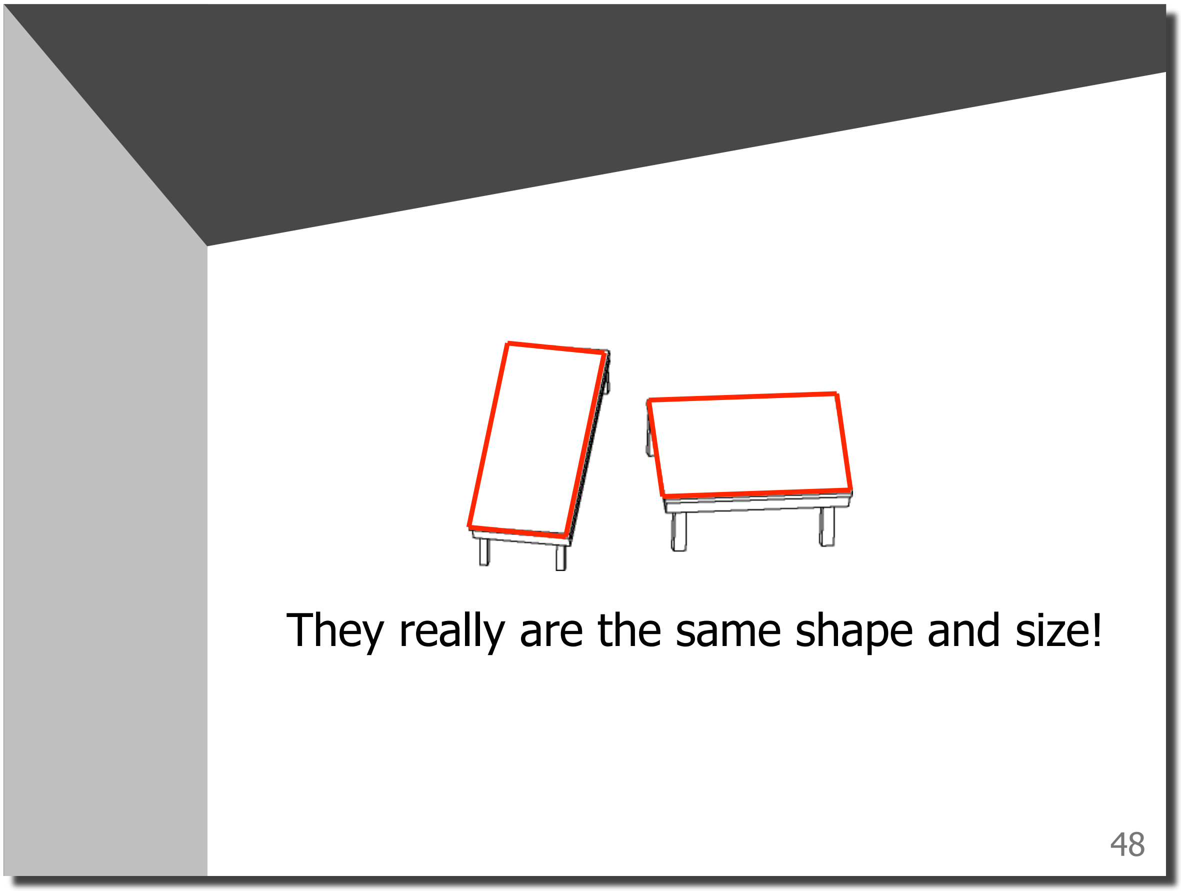
Break – visual illusions!



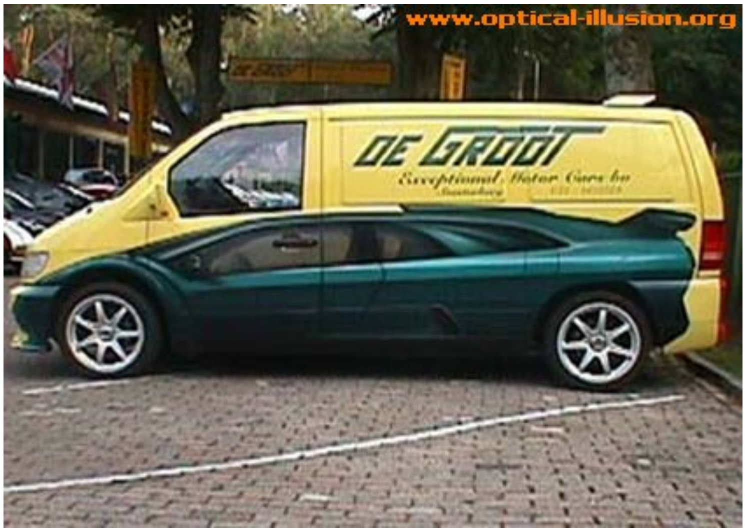


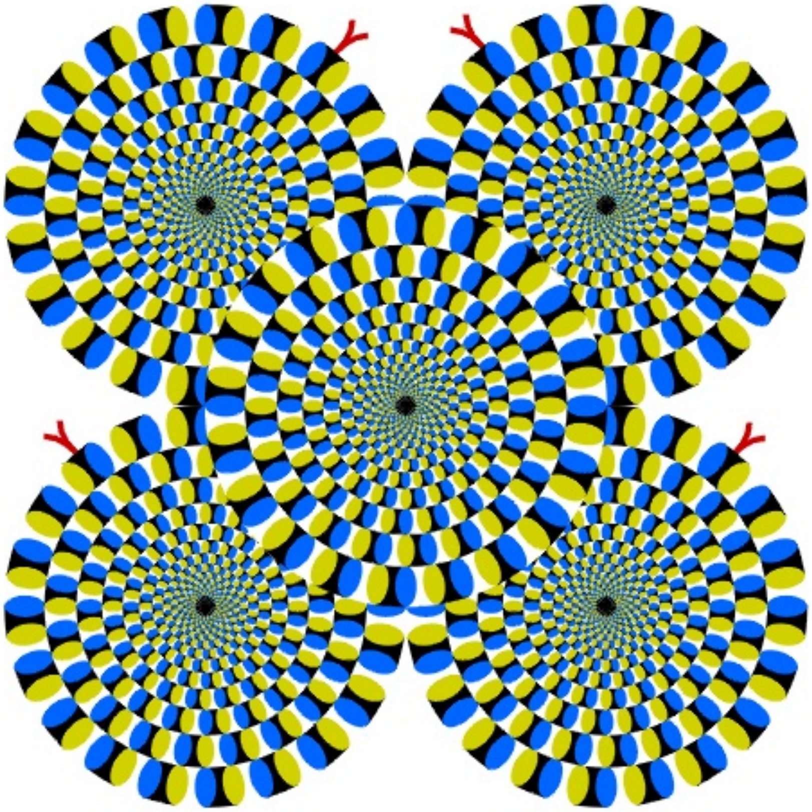






They really are the same shape and size!

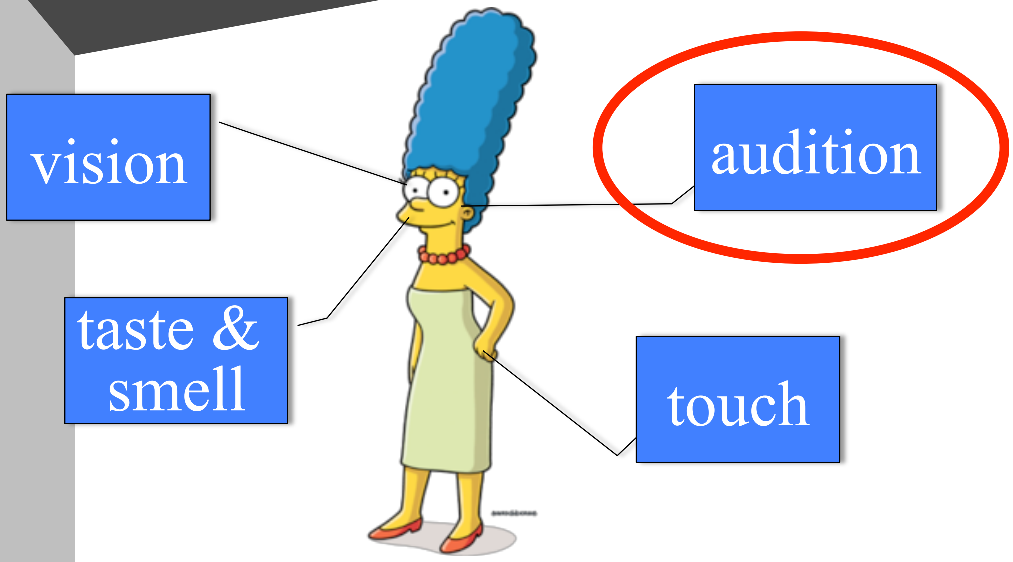

www.optical-illusion.org
DE GROOT
Exceptional Motor Cars bv



If you like illusions …

- http://illusionoftheyear.com/
- http://gethighnow.com/ (also some auditory ones)

Perceptual Systems



vision

audition

taste & smell

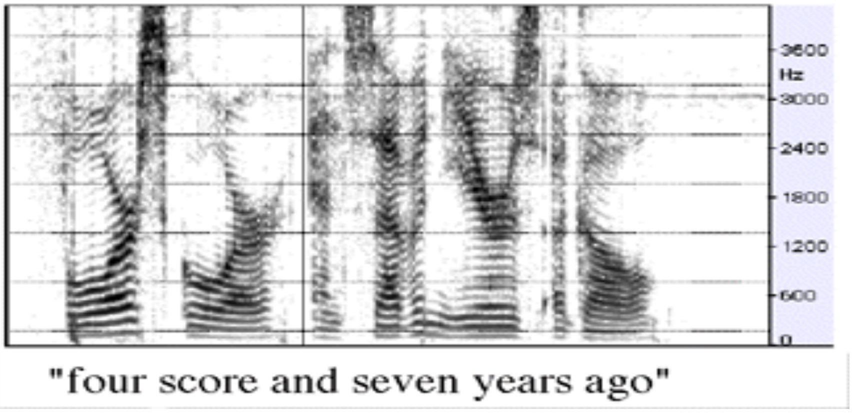
touch

AUDITORY PROCESSING

- Does the mind "hear" the world for what it is?
    - *or instead offer an interpretation of it?*

Speech spectrogram

- The speech stream is continuous.



"four score and seven years ago"

Hey, where are the words??

Ambiguity

Where are the word boundaries?

"Olive, the other reindeer …"
  (Rudolph the Red-nosed Reindeer)
"There's a bathroom on the right …"
  ("Bad Moon Rising" Creedence Clearwater Revival)

"Mondegreens"

Variability in sound production

How a particular sound (phoneme) is pronounced depends on:

- the speaker
- the speech rate
- emotional factors
- the sound environment ("coarticulation")

Categorical Perception

- The auditory system "exaggerates" differences between sounds.
  - For example, sounds "in between" BA and PA are heard as one or the other.
- Babies start out showing categorical perception for all possible sound contrasts.
- If those contrasts don't matter in your language(s), the auditory system learns to ignore the difference.

Context effects

- Like the visual system, the auditory system uses context:
  - topic of conversation
  - recent words
  - recent sounds
- Context can also come from other sensory modalities …

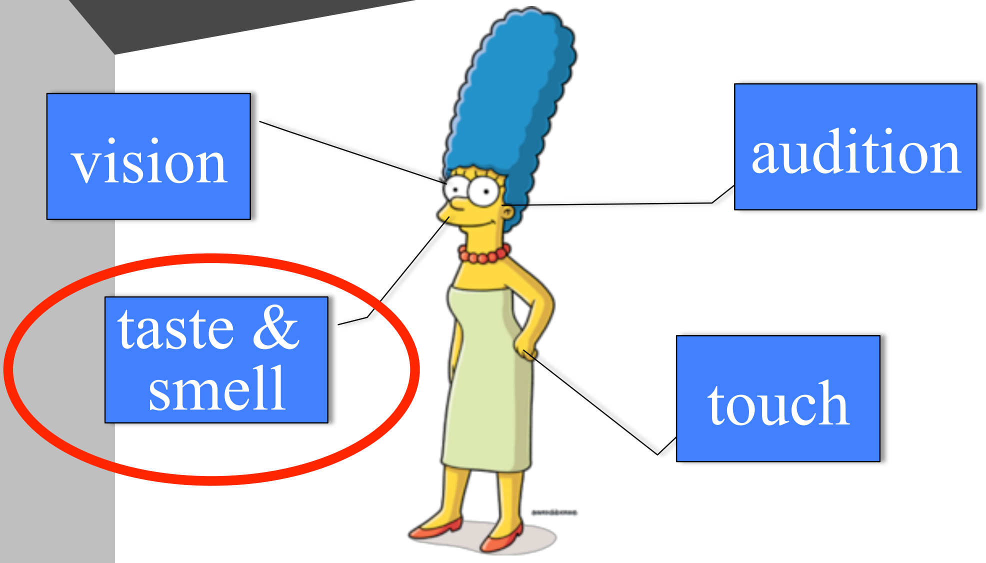
McGurk Effect

Audition: Summary

There is also a lot of ambiguity in auditory processing (especially speech)

- Built-in strategies for dealing with variability (categorical perception) help.
- Also make use of context information and cues from other senses.

Perceptual Systems



vision

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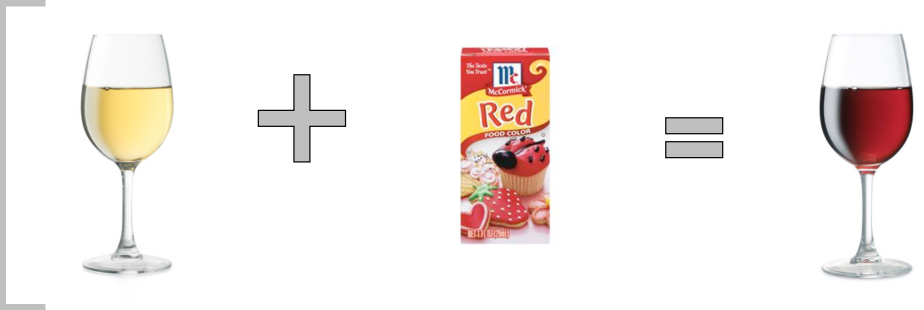
taste & smell

touch

Taste & Smell

- Context guides taste perception



Taste & Smell

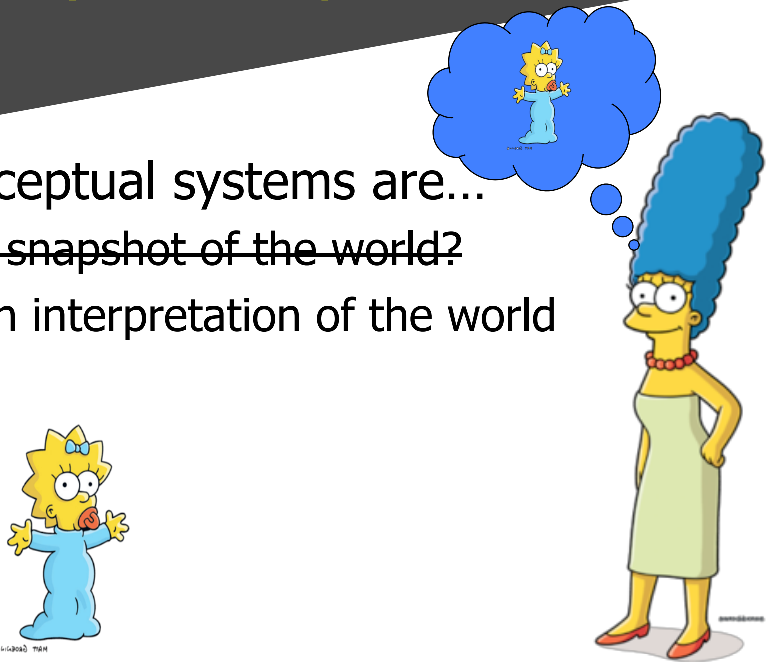
- Context guides taste perception

Summary: Perception

- Perception involves
  - *integration* across senses
  - use of *contextual* knowledge
    - from the world
    - from memory
  - *interpretation* of input

Summary: Perception

- Perceptual systems are…
  - ~~a snapshot of the world?~~
  - an interpretation of the world



Thought question

Imagine you are building an artificial vision system. Your system first uses grouping principles to determine how many objects are in the scene. Next, the features of each object are extracted. Finally, each object is identified serially, by comparing the features for that object with feature lists stored in memory.

How will your system behave if you ask it to identify an object presented in isolation as compared with an object in a complex scene?

Is this similar to the pattern we would expect to see for humans? Why or why not?